Measurement and Analysis of Atmospheric Stability in Two Texas Regions

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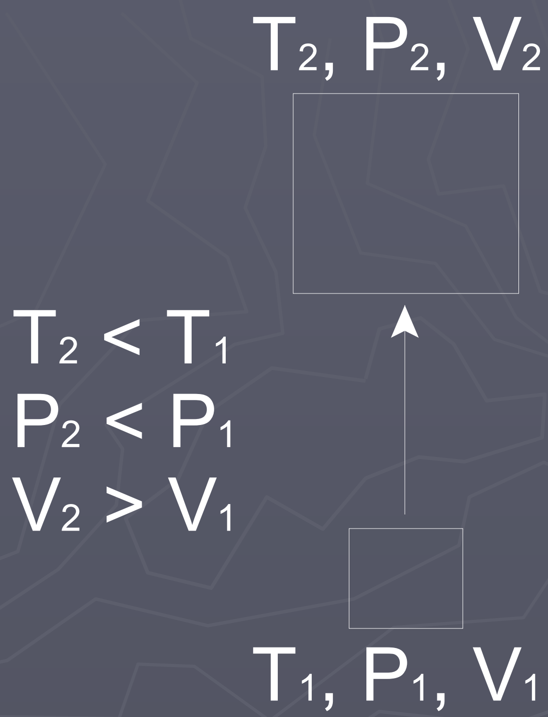
Atmospheric Stability – Lapse Rate

- Lapse Rate
  - Rate at which temperature varies with height
- Adiabatic Lapse Rate
  - Rising parcel of air
  - Adiabatic Expansion
  - Temp decreases approx. 0.55 °F per 100 ft (1 °C per 100 m)
- Actual Lapse Rate
  - > Adiabatic lapse rate – **Unstable**
    - Rising parcel's temperature > and density < than surrounding air
      - Vertical motion enhanced
  - = Adiabatic lapse rate – **Neutral**
    - Rising parcel's temperature and density same as surrounding air
      - Equilibrium
  - < Adiabatic lapse rate – **Stable**
    - Rising parcel's temperature < and density > than surrounding air
      - Vertical motion opposed



Stability Ratio

- Stability Ratio (SR) is a function of actual lapse rate and wind speed

$$SR = \frac{T_1 - T_2}{u^2} \cdot 10^5$$

T_1 = temp (°C) at 10 m

T_2 = temp (°C) at 2.5 m

u = wind speed (cm/sec) at 5 m

Stability Ratio Classes

Atmospheric Stability Condition	Stability Ratio Range
Unstable	-1.7 to -0.1
Neutral	-0.1 to 0.1
Stable	0.1 to 1.2
Very Stable	1.2 to 4.9

Atmospheric stability classes by stability ratio as defined by Yates, et al. (1974).

Effects of Atmospheric Stability

- Yates et al. (1966)
  - Over 3 times deposition under very stable versus unstable
- Yates et al. (1967)
  - Wind speed dominates in near field
- MacCollom et al. (1986)
  - Greater drift distance and amounts under temperature inversions
- Hoffman and Salyani (1996)
  - Higher depositions for nighttime versus daytime applications

Effects of Atmospheric Stability

- Bird (1995)
  - Highest drift under relatively high wind speeds coupled with temperature inversions and small droplet spectra
- Miller et al. (2000)
  - Atmospheric stability dominates in far field
  - Increased wind speed and stable conditions important factors in higher drift amounts
  - 2 – 6 times the amount of drift under unstable conditions versus stable conditions

Atmospheric Stability Research

- Objectives
  - Monitor and analyze meteorological conditions to develop a probability assessments of atmospheric stability and inversions as related to time of day, wind velocity, and other meteorological parameters at several crop production areas in Texas
  - Field studies to assess spray drift and deposition under varying atmospheric stability conditions.
  - Further field studies incorporating biological assessments of efficacy to determine impact of spray applications under different atmospheric stability conditions.
  - Use of in-flight instrumentation to measure meteorological parameters and atmospheric stability

Monitoring and Documentation of Atmospheric Stability

- Construction of 2 meteorological monitoring towers
  - Temperature – 0.5, 2.5, 5, 7.5, and 10 meters
  - Wind Speed – 2.5 and 10 meters
  - Wind Direction – 2.5 meters
  - Solar Radiation – 2.5 meters

Monitoring and Documentation of Atmospheric Stability

- Station 1
  - Erected near College Station, TX
- Station 2
  - Erected near Wharton, TX
- Data recorded in 1 minute intervals from May 2003 thru October 2003

Results of Data Analysis
Wind Speed

Weather Station 1

	Yates et al. (1974) Atmospheric Stability Classes			
Wind Speed – mph (m/s)	Unstable	Neutral	Stable	Very Stable
Average	7.6 (3.4)	11.6 (5.2)	5.8 (2.6)	2.7 (1.2)
Standard Deviation	4.0 (1.8)	4.3 (1.9)	2.0 (0.9)	1.6 (0.7)

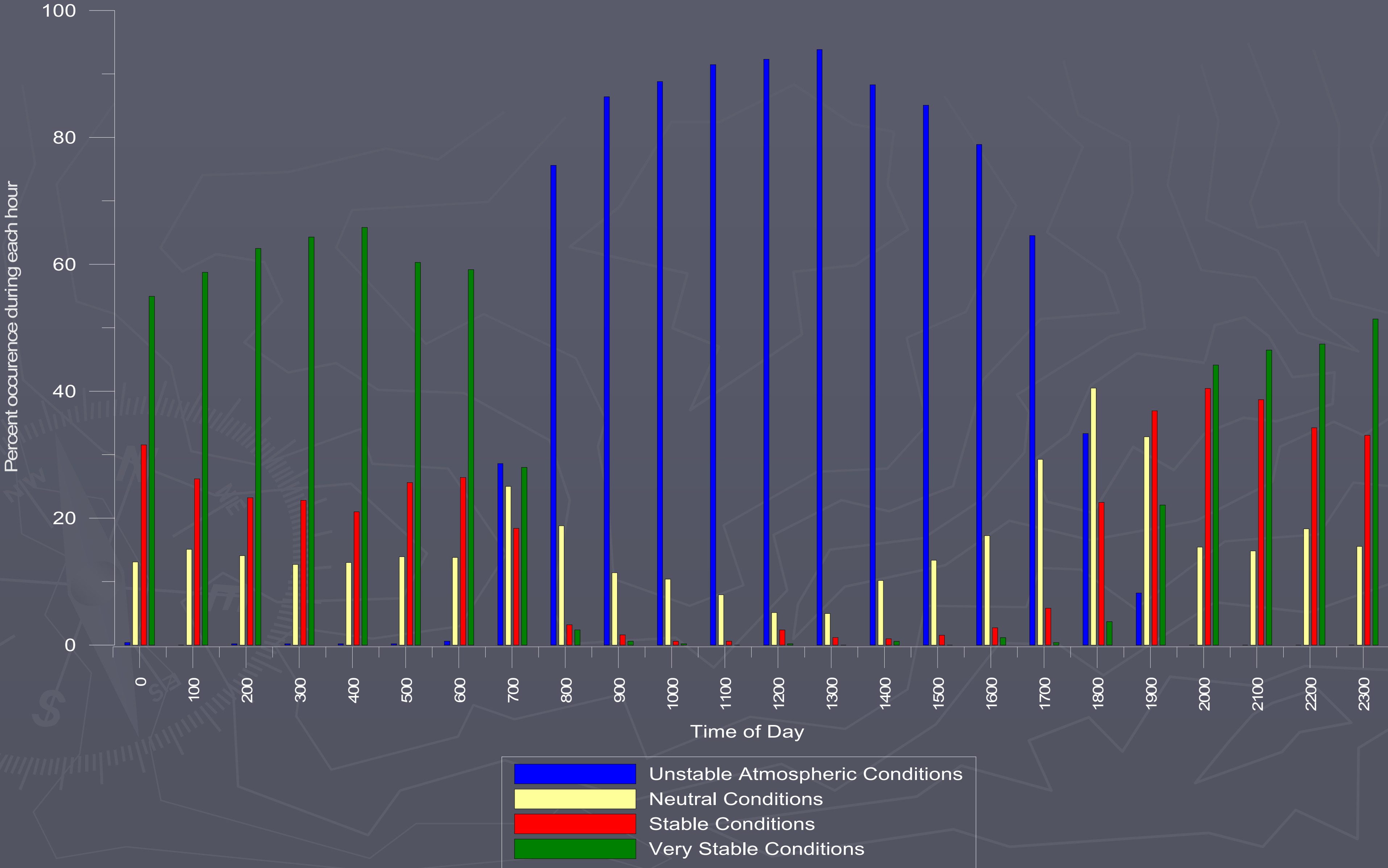
Weather Station 2

	Yates et al. (1974) Atmospheric Stability Classes			
Wind Speed – mph (m/s)	Unstable	Neutral	Stable	Very Stable
Average	7.8 (3.5)	11.6 (5.2)	6.5 (2.9)	3.1 (1.4)
Standard Deviation	4.3 (1.9)	4.7 (2.1)	2.0 (0.9)	1.6 (0.7)

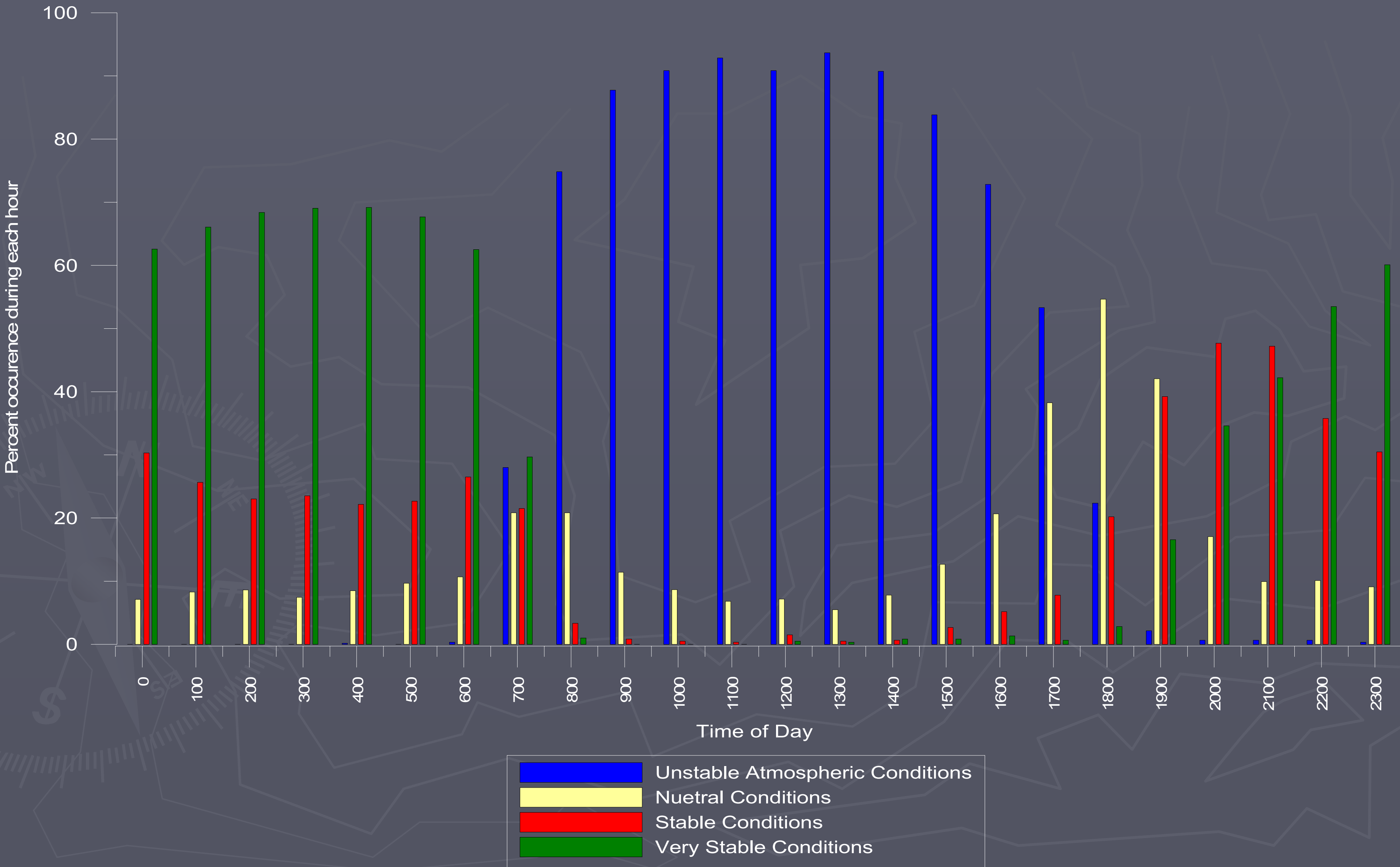
Wind Speed

- "Rules of Thumb"
  - Wind speeds above 6 mph generally indicate neutral or unstable conditions.
  - Wind speeds below 3 mph generally indicate very stable conditions.
- For all recorded inversion periods
  - Station 1
    - Wind speed average – 4.9 mph (2.2 m/s)
    - Wind speed standard deviation – 3.6 mph (1.6 m/s)
  - Station 2
    - Wind speed average – 5.1 mph (2.3 m/s)
    - Wind speed standard deviation – 3.4 mph (1.5 m/s)

Probability Distribution of Stability Classes by Time of Day
Station 1



Probability Distribution of Stability Classes by Time of Day
Station 2



Daily Cycle of Stability

- Daytime hours (7 a.m. to 5 p.m.)
  - Tend to be dominated by unstable conditions followed by neutral conditions.
  - There are occurrences of both stable and very stable conditions.
- Nighttime hours (7 p.m. to 6 a.m.)
  - Tend to be dominated by very stable conditions followed by stable and neutral conditions.
  - There were some occurrences of unstable conditions
- Transitional hours (7 a.m. and 6 – 7 p.m.)
  - Conditions changing.
    - Unstable daytime conditions to Stable nighttime conditions.
    - Stable nighttime conditions to Stable daytime conditions.

Inversions
6 a.m. to 6:30 p.m.

	Meteorological Station 1 Total of 136 Days Monitored			Meteorological Station 2 Total of 155 Days Monitored		
		Percent of Total Days Monitored			**Percent of Total Days Monitored**	
Number of Days One or More Inversion Events Occurred	78	57%	**Percent of Total Inversion Days**	101	65%	**Percent of Total Inversion Days**
Number of Morning Inversion Events	20	15%	26%	34	22%	34%
Number of Mid-day Inversion Events	26	19%	33%	36	23%	36%
Number of Evening Inversion Events	61	45%	78%	77	50%	76%

Inversions – Duration and Strength

Station 1

		Start Time	Duration (min)	Strength* (ΔT °C)
Morning	Average	8:27 a.m.	35	0.17
	Standard Deviation	n/a	57	0.10
Mid-day	Average	2:39 p.m.	27	0.16
	Standard Deviation	n/a	27	0.17
Evening	Average	6:04 p.m.	376	0.30
	Standard Deviation	n/a	392	0.29

Station 2

		Start Time	Duration (min)	Strength* (ΔT °C)
Morning	Average	8:22 a.m.	17	0.09
	Standard Deviation	n/a	20	0.05
Mid-day	Average	1:24 p.m.	32	0.15
	Standard Deviation	n/a	52	0.14
Evening	Average	6:11 p.m.	236	0.24
	Standard Deviation	n/a	355	0.28

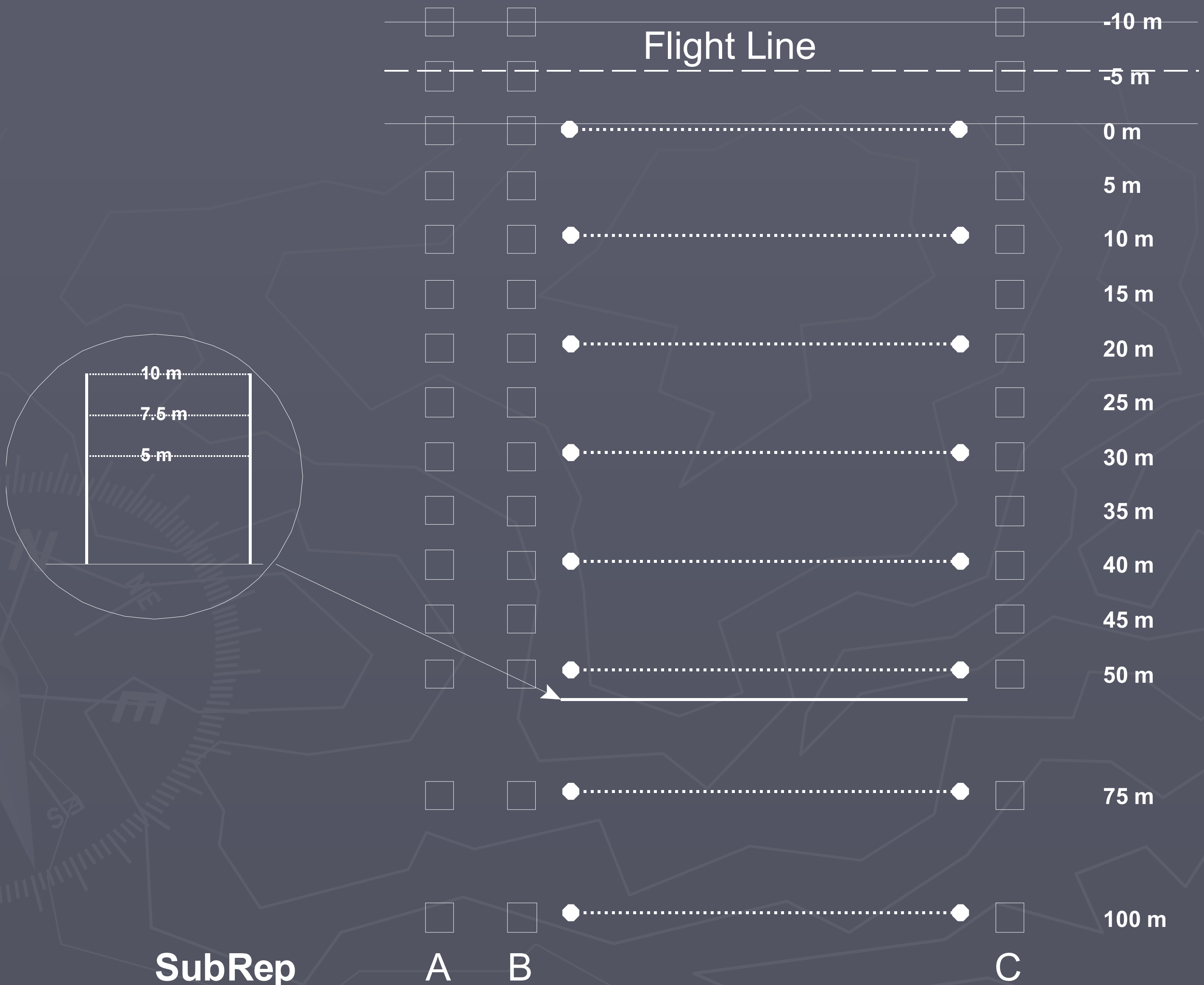
Conclusions

- Station 1
  - 57% of the days had inversions between 6 a.m. and 6:30 p.m.
- Station 2
  - 65% of the days had inversions between 6 a.m. and 6:30 p.m.
- For both stations 1 and 2 more than half of the inversions occurred after 4 p.m.
- Afternoon inversions of most concern
  - Much longer in duration
  - Greater in strength (temperature difference)
- Evening applications would have a greater probability of being significantly influenced by stable to very stable or inversion conditions

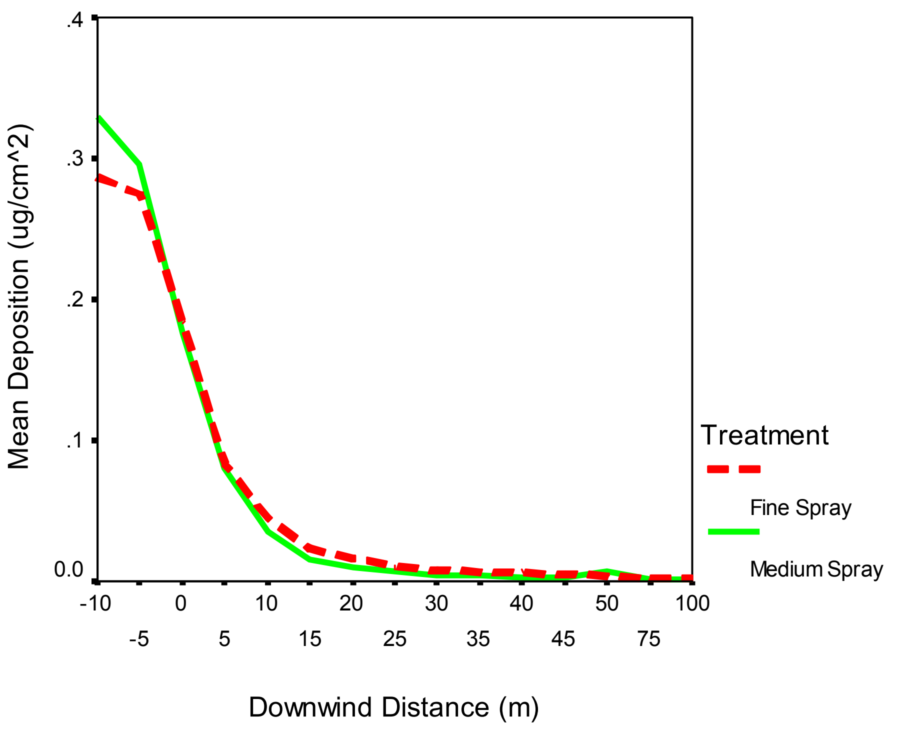
Field Study – Preliminary Results

- Objective
  - To measure spray drift and deposition under stable to very stable atmospheric conditions versus unstable conditions.
- Two treatments
  - Fine Spray
  - Medium Spray
- Sampling
  - Mylar cards
  - Elevated monofilament
  - Tower with monofilament

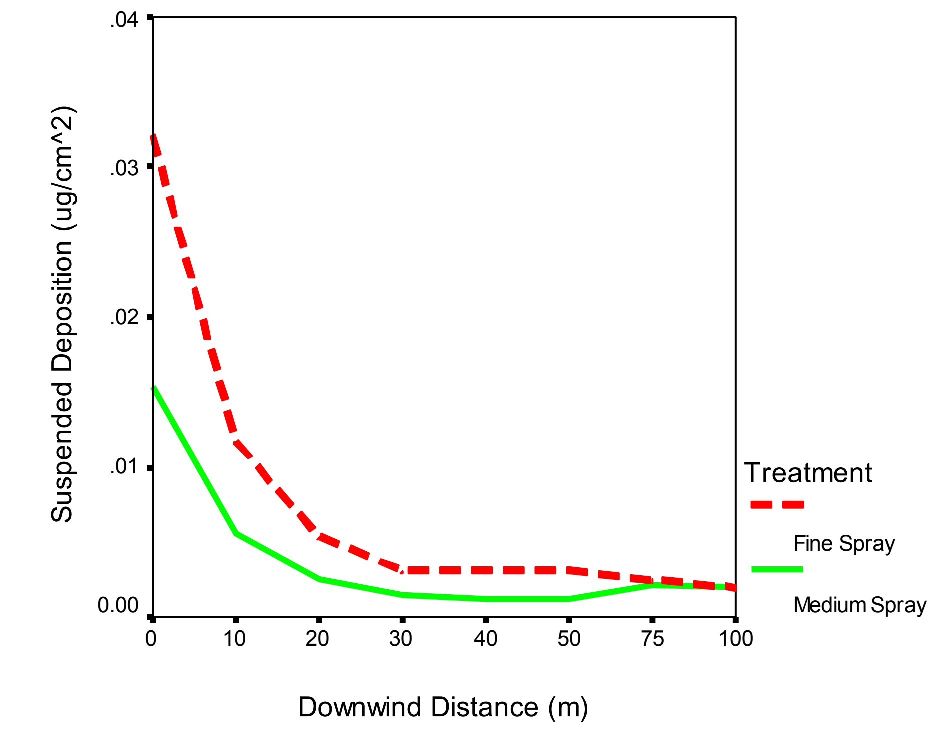
Field Study – Preliminary Results



Field Study – Preliminary Results

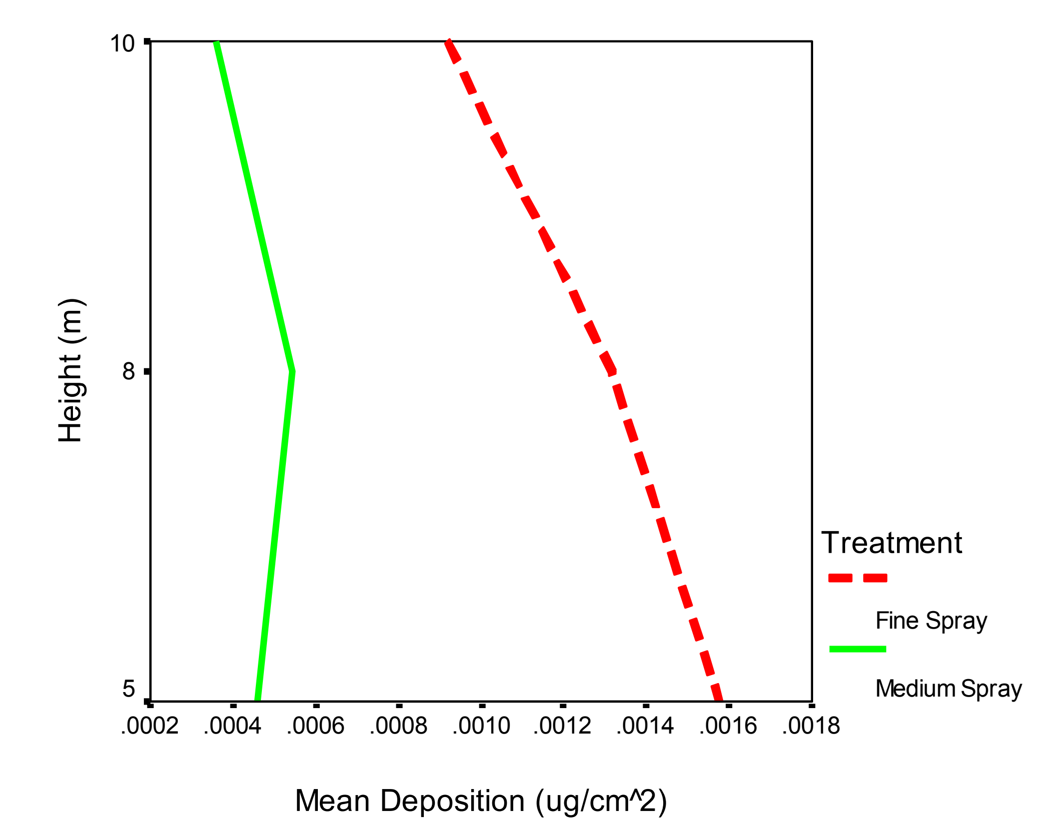


Ground Deposition - Mylar



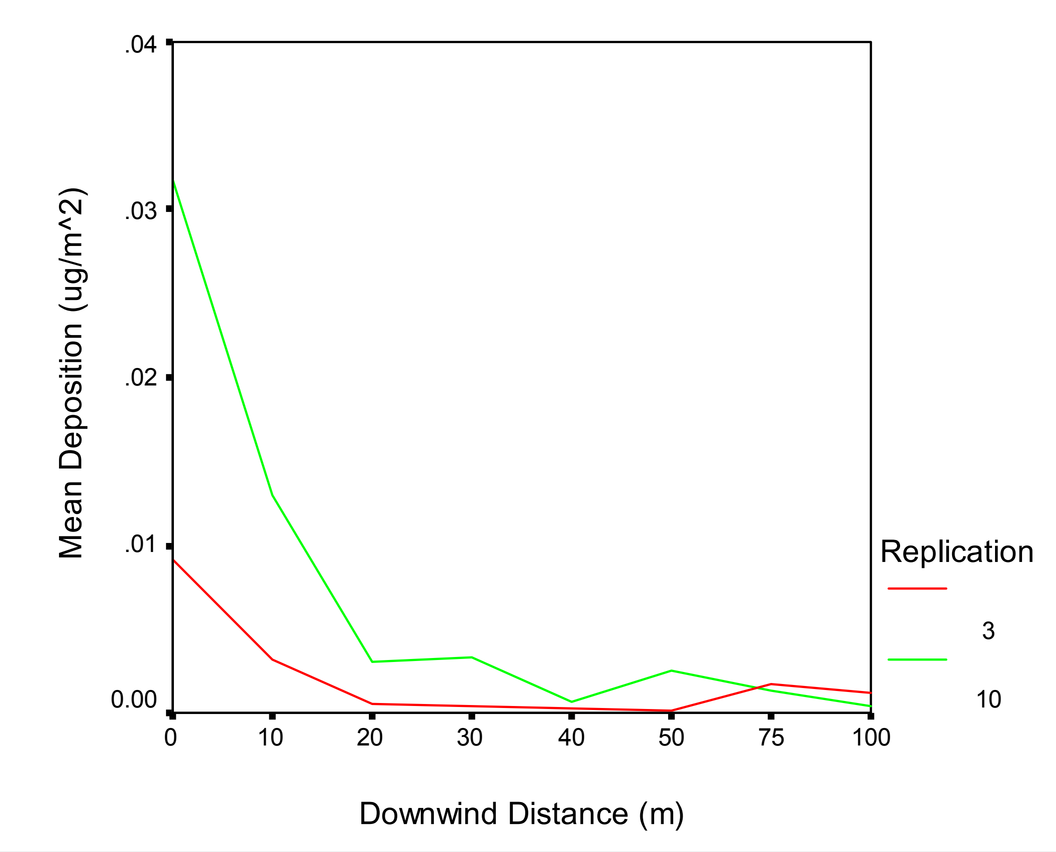
Suspended Concentration - Monofilament

Field Study – Preliminary Results



Tower - Monofilament

Field Study – Preliminary Results



Suspended Concentrations – Monofilament

Treatment 2 – Reps 3 and 10

- Both Reps during Unstable Conditions
- Rep 3
  - Horizontal WS
    - 0.1 mph
  - Vertical WS
    - 1.6 mph (upward)
- Rep 10
  - Horizontal WS
    - 4.1 mph
  - Vertical WS
    - 0.1 mph (downward)

Future Research

- Additional field studies
  - Evening sampling to better capture stable/very stable/inversion conditions.
  - Mid-day sampling for Unstable conditions.
  - Biological assessment of spray efficacy under varying stability conditions.
- Integration of Aventech AIMMS 20 in-flight meteorological monitoring system.